Monitoring Internal Lepidoptera to Prevent Worms in Fruit, 2003-2004

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Funding:
Motts Inc., Williamson, NY
Gowan Company, LaFayette, NY
Subscribers to Fruit Fax, published by the Lake Ontario Fruit Program

Background and Justification:

Western New York has approximately 28,000 acres of apples, 700 acres of pears, and 1200 acres of peaches. Observations made in apples, pears, and peaches across the region in 2002 showed that internal lepidopteran larvae are infesting fruit at increased economic levels. The primary species are *Grapholitha molesta*, oriental fruit moth (OFM), *Cydia pomonella*, codling moth (CM), and *Grapholitha prunivora*, lesser appleworm (LAW). The number of processing apple loads rejected at processors due to presence of worms increased from 30 loads from 12 growers in 2001 to 113 loads from 48 growers in 2002. Every truckload of apples rejected as canners diverting them to juice reduced their value by $1500 per load (a drop in value from ~ 8 cents for processing apples to juice at ~ 4 cents per pound), if they have a juice market at all. In the Mid-Atlantic state, the number of loads rejected due to internal worms has increased from one year to the next to >800 loads in 2004.

Scientists experiencing the same problems in other regions suggest possible reasons for the increased infestation by internal lepidoptera include 1) the reduction in the use of broad-spectrum insecticides such as organophosphates (OPs), 2) the development of resistance to those insecticides, and 3) the reliance on more selective insecticides to control other pests in the complex that are not efficacious against OFM and/or codling moth CM.

Tools available for control of internal lep management in NY include azinphos-methyl, pyrethroids, phosmet, Avaunt, and mating disruption. NYS DEC registered the use of Intrepid and Assail in 2004 to assist in control of CM and OFM. Mating disruption used in areas on a region-wide scale has been successful in reducing the population of OFM after a couple of years but the level of control has not eliminated the need for well-timed insecticides. CM is more difficult to disrupt, and requires very large areas under mating disruption. Orchards with mixed population of OFM and CM are especially challenged since these two pests have different critical timings necessary for insecticide application. OFM has 3-4 generations per season, and CM, 2 generations per season. Although insecticides will still be required in control of OFM, there is potential to minimize pesticide inputs in controlling OFM using proper timing and mating disruption.

Objectives:

1) Expand educational programs to implement IPM strategies for internal lep pests.
2) Increase the efficiency and publicity of the OFM/CM trapping network.

Procedures:

Objective 1: Expand educational programs to implement IPM strategies for internal lep pests.

A series of educational opportunities in integrated pest management strategies for internal lep pests in apples, pears, and peaches included the following:

- ***The 2003 LOF Winter Fruit Schools -*** Dr. Larry Hull from PSU, presented the most current research results on biology of OFM and CM and the best control timings based on a degree day model under development in conjunction with trap catch information.
- ***International Dwarf Fruit Tree Association Annual Conference in Syracuse, NY (Feb., 2003) -*** The Lake Ontario Fruit Program arranged a special educational session at this conference, inviting entomologists from Pennsylvania, New Jersey, Michigan, Washington, and New York.
- ***Workshop to Manage Worm Outbreaks in Fruit -*** The Lake Ontario Fruit Program held workshop in two sites in Western New York on March 19, 2003, with Cornell faculty, extension, IPM Fruit coordinator, and representatives from companies with NYS registered materials.
- ***Field meetings, 2003 -*** LOF reviewed the identification, and control strategies and timings with hands on demonstrations.
- ***The Empire State Fruit and Vegetable EXPO, 2004 -*** Two presentations covered internal lep control in peaches and apples including mating disruption and insecticide controls and timings that worked in 2003.
- ***Scout training –*** LOF conducted field training for scouts who would be responsible for finding and identifying signs of infestation.
- ***Fruit Notes (the LOF newsletter) and Fruit FAX in 2003-04 -*** Timely reminders were included in newsletters, faxes, and emails on the flight status and potential egg hatch to control newly hatched larvae before they enter the safe harbor of the flesh of the fruit.

Objective 2: Increase the efficiency and publicity of the OFM/CM trapping network.

In 2003 and 2004, a trapping network was expanded across the Western New York fruit belt. A total of 150 traps were installed across the region: 2 Pherocon IIB traps per block for OFM, CM, and LAW. The summer technician counted and removed moths in traps once per week. Counts were gathered and summarized by Lake Ontario Fruit Program-CCE to incorporate into Fruit Notes, emails, and Fruit FAX, all available to growers, consultants, distributor field reps, and faculty. These counts assisted growers to properly time mating disruption and insecticide applications and can contribute to validating the PSU degree-day model for OFM under development.

The trap catch data was graphed using total moths caught per trap per season, for each species. And the trap catch data per week for each farm was graphed to detect peak flight of each generation, with theoretical DD based spray dates, and actual spray dates. These data will be reviewed with cooperating growers through the winter months to assist in planning for 2005 controls.

Results:

Objective 1:

- ***The 2003 LOF Winter Fruit Schools -*** Over 200 growers and consultants attended the Winter Fruit Schools. We raised awareness of some research about the biology of the OFM, CM and LAW, and successes in controlling these pests with mating disruption, and old and new insecticides. L. Hull gave a comprehensive presentation of research findings from his

research team over the past 4 years. We used some of this research as a foundation for the Spring workshop.

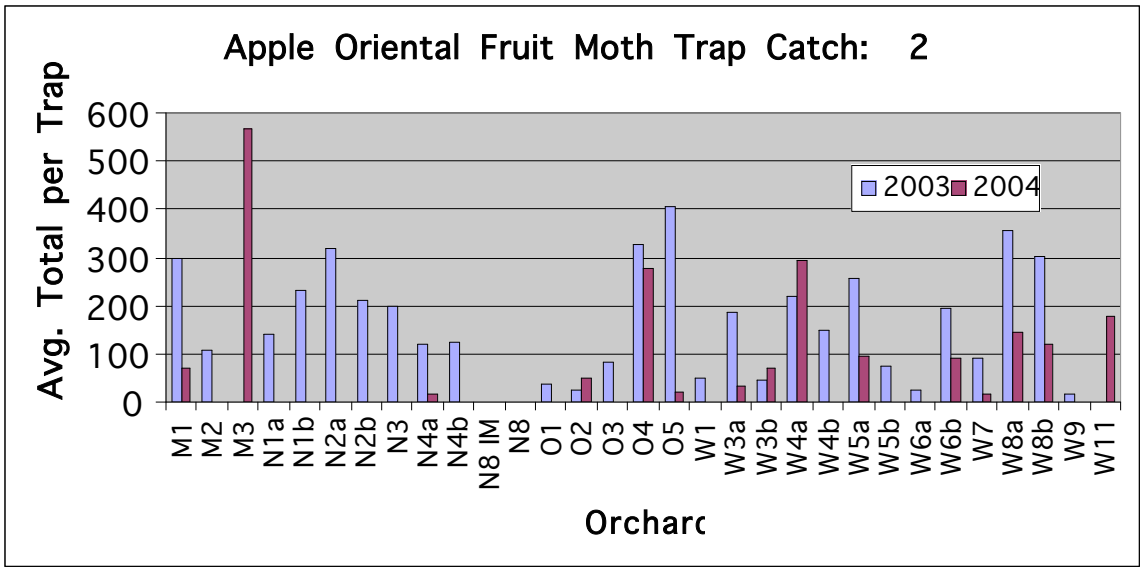
- ***International Dwarf Fruit Tree Association Annual Conference in Syracuse, NY (Feb., 2003) -*** Consultants and growers with chronic problems controlling internal lep pests learned about the biology, monitoring with pheromone traps, the pitfalls in mating disruption for OFM and CM, and the insecticide timing models that could be incorporated dependent on the insecticide class selected. Research presented in this forum also served as a foundation for the Spring workshop.
- ***Workshop to Manage Worm Outbreaks in Fruit -*** Growers from 35 farms, and 13 consultants from western New York attended the March workshop. They learned how to identify the distinguishing characteristics of OFM/CM/LAW. They learned about the differences in biology and signs of infestation. They learned about how to monitor for these pests using pheromone traps, and looking for the signs of infestation in shoots and fruit. They learned how to use mating disruption pheromones for control of OFM and to determine if mating disruption was an appropriate control strategy based on population level, size and shape of orchard, density of tree canopy, and evaluating the orchard surroundings. They also learned about how to use degree-day models to better time insecticide applications when they are necessary, and how effective the new and old insecticides registered in New York are for controlling internal lep pests. A notebook was included to use as a reference throughout the season.

  Of growers who attended the workshop, only one farm had a single load rejected in the harvest of 2003. While Pennsylvania fruit rejections continued to increase to numbers greater than 600 in 2003, there were a total of 13 loads from 11 growers rejected at one processor in Western New York for worms. In 2004, PA truck load rejections increased to over 800; in Western NY, there were 16 loads rejected by 2 processors, 5 of which were due to infestation by dock sawfly. However have heard of 12 loads of NY apples rejected at PA processors.
- ***Field meetings, 2003 -*** Approximately 40 growers attended the April Workshops where we demonstrated the installation of pheromone traps, discussed the best location of traps, and distributed colored fact sheet highlighting distinguishing physical characteristics of adult moths, larvae, and signs of infestation. Over 100 growers and 10 consultants attended the late May workshop where they had the opportunity to confirm their ability to identify adult OFM, CM, And LAW, next to the many imposters that are also caught in the traps. Lake Ontario Summer Fruit Tour in Wayne Co. included a tour stop where samples of larvae, adult moths, and infested shoots and fruit were available for over 100 growers, and consultants to become familiar with these pests.
- ***The Empire State Fruit and Vegetable EXPO, 2004 -*** Approximately 250 growers attended the 2 sessions. Field meetings followed to help growers discriminate between other insects caught in pheromone traps and actual OFM, CM, and LAW.
- ***Scout training –*** Trained 7 summer scouts (5 of which work for a private consultant) to identify the various internal lep adults and larvae. Identification is the first step critical step to choosing a management strategy.
- ***Fruit Notes (the LOF newsletter) and Fruit FAX in 2003-04 -*** Over 100 subscribers received the pest status updates through fax or email, and 460 enrollees received the updates through newsletters.

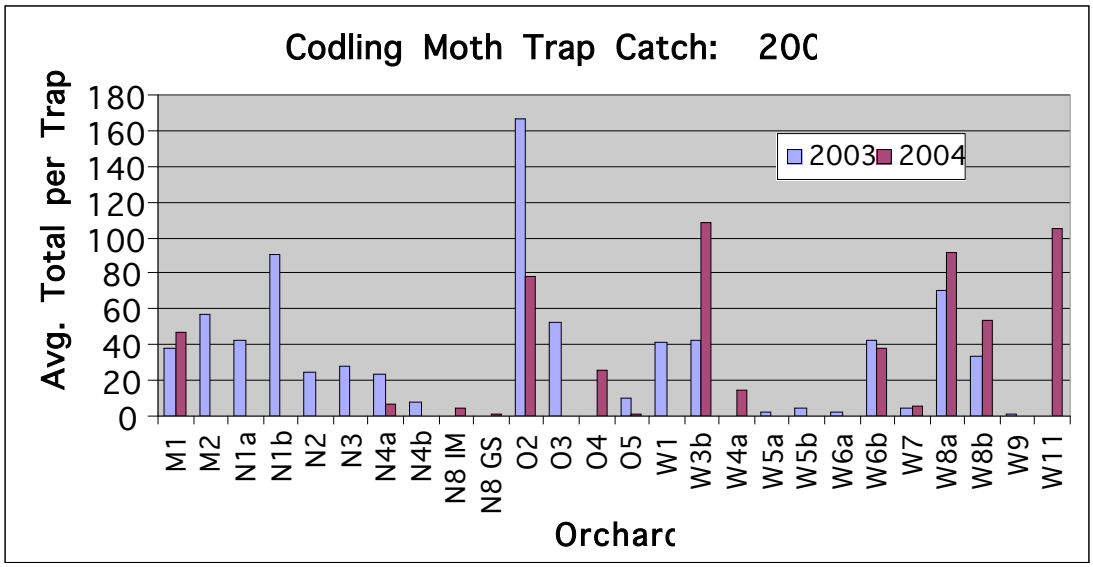
Objective 2. Trap catch results

In 2003, pheromone baited sticky traps were set in a total of 21 farms in late April, in 2004, the number of farms was reduced due to reduced funding. Initially, growers were very diligent about checking traps and calling or emailing the data. But as the season progressed, we found that the growers were not able to dedicate specific days since they were also the ones who had to plan for other activities based on the weather. By mid-season, the technician was mainly responsible for checking and cleaning traps weekly, and replacing lures and trap bottoms on a regular schedule. In general, growers who did not have regular visits from a consultant or fieldman were willing to continue the effort at monitoring for these internal pests and expressed gratitude for the educational efforts through Cornell Cooperative Extension and IPM. The growers who were interested in checking traps learned about imposters that were also attracted to the traps, but not traditional fruit pests.

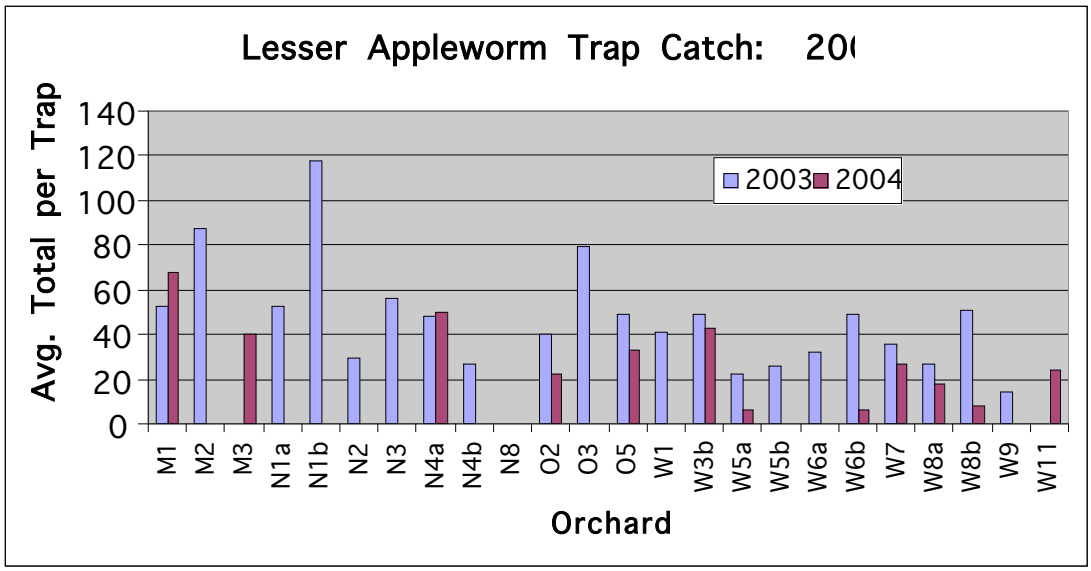
Figures 1-3 show there is a lot of variability in pressure from each of the internal



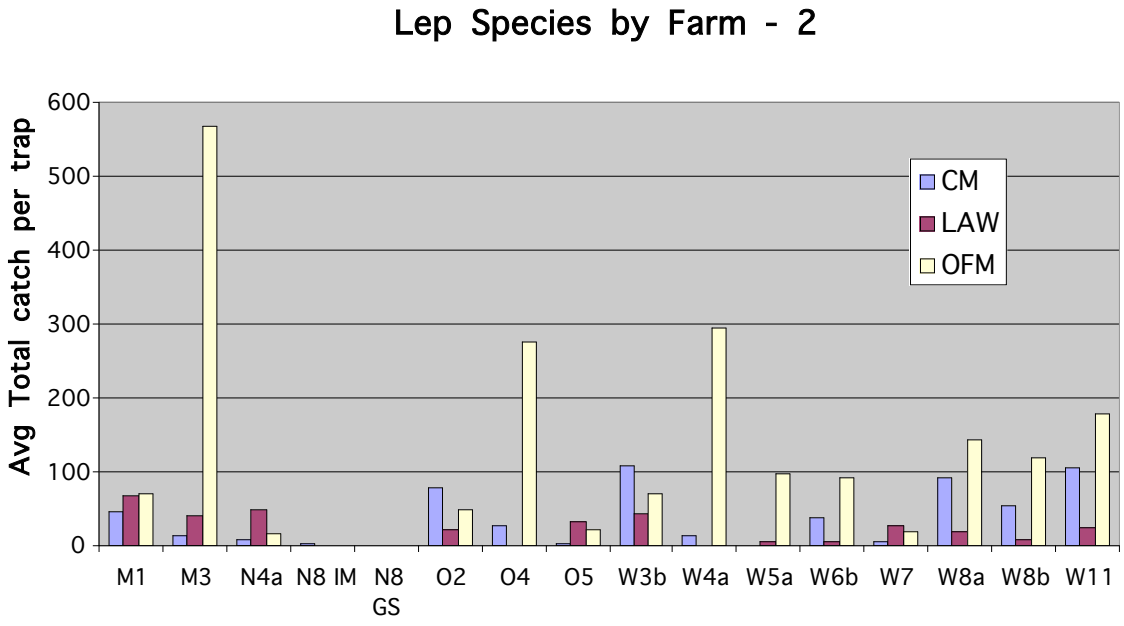
lepidopteran pest species from one farm to another. Figure 1 shows that the total number of OFM moths trapped per block for the entire season ranged from 17-403 in 2003, and 16-568 in 2004. Figure 2 shows that CM in general is not a major issue for most of western New York except for



a few high-pressure locations. The total CM moths caught per trap per season ranged from less than 5 – 167 in 2003, and 1-108 in 2004. Figure 3 shows a third pest, lesser appleworm, is also a



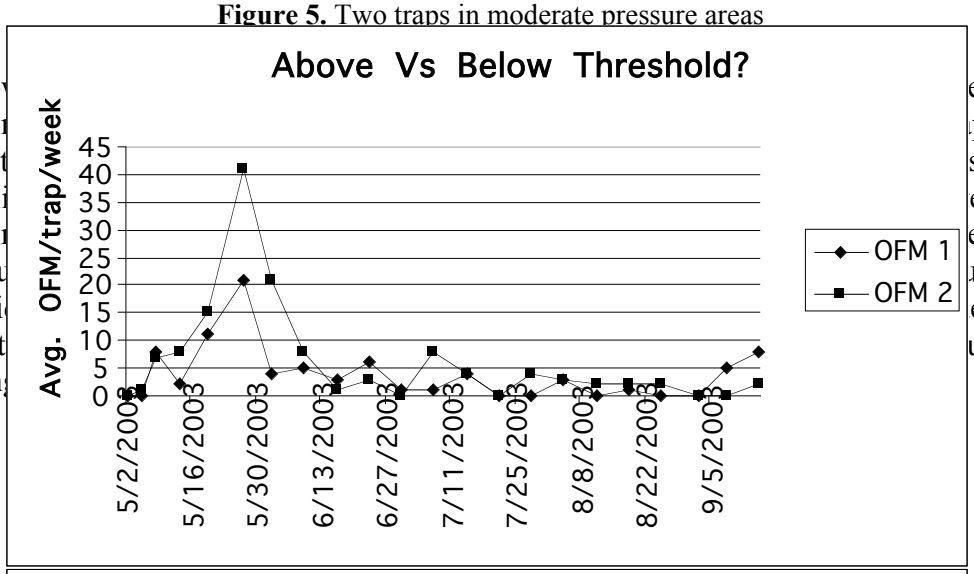
factor in the internal lep complex. Lesser appleworm trap catch ranged from 14-117 in 2003, and 6-68 in 2004. Figure 4 shows how individual orchards differ in the predominant pest species in 2004. In 2003 for example, "O5" had the highest number of OFM, very few CM, and moderate levels of LAW. "O2" had the highest CM trap catch, one of the lowest OFM trap catches, and moderate levels of LAW. "W9" had very low populations of all 3 lep species. "N1b" had high



populations of all three species. In 2004, M3 and W4a had very high levels of OFM, but low populations of other pests. O2 and W3b had higher populations of CM than OFM. Since CM was a significant factor in 4 of 14 sites monitored, it is critical for growers to survey the population of at least OFM and CM on their farms to determine the appropriate control strategies.

The variability in populations of internal lep species can only be detected with the installation and maintenance of traps for each species on the farm. The questions still remain: How many traps per farm or per block are necessary, and practical to obtain the necessary information? And where should the traps be hung, on the edge or inside the orchard?

Figure 5. Two traps in moderate pressure areas



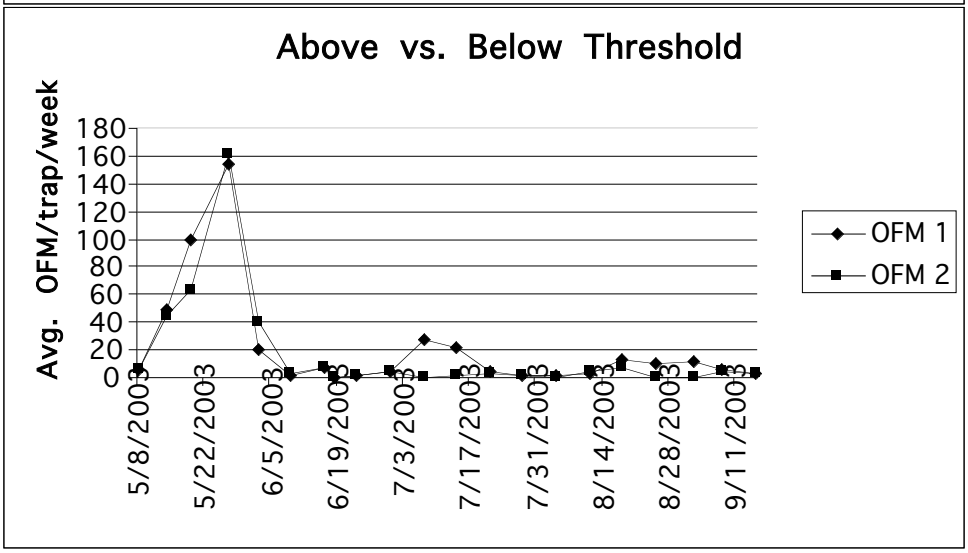


Figure 6 shows how weekly trap counts in 2003 differ between adjacent farms. This can depend on spray schedules and insecticides used. This also emphasizes the importance of monitoring each farm. The last chart in Figure 6 demonstrates peak flight timing, used in timing insecticide applications, may differ from one trap location to another on the same farm. So regional spray programs may not be accurate enough.

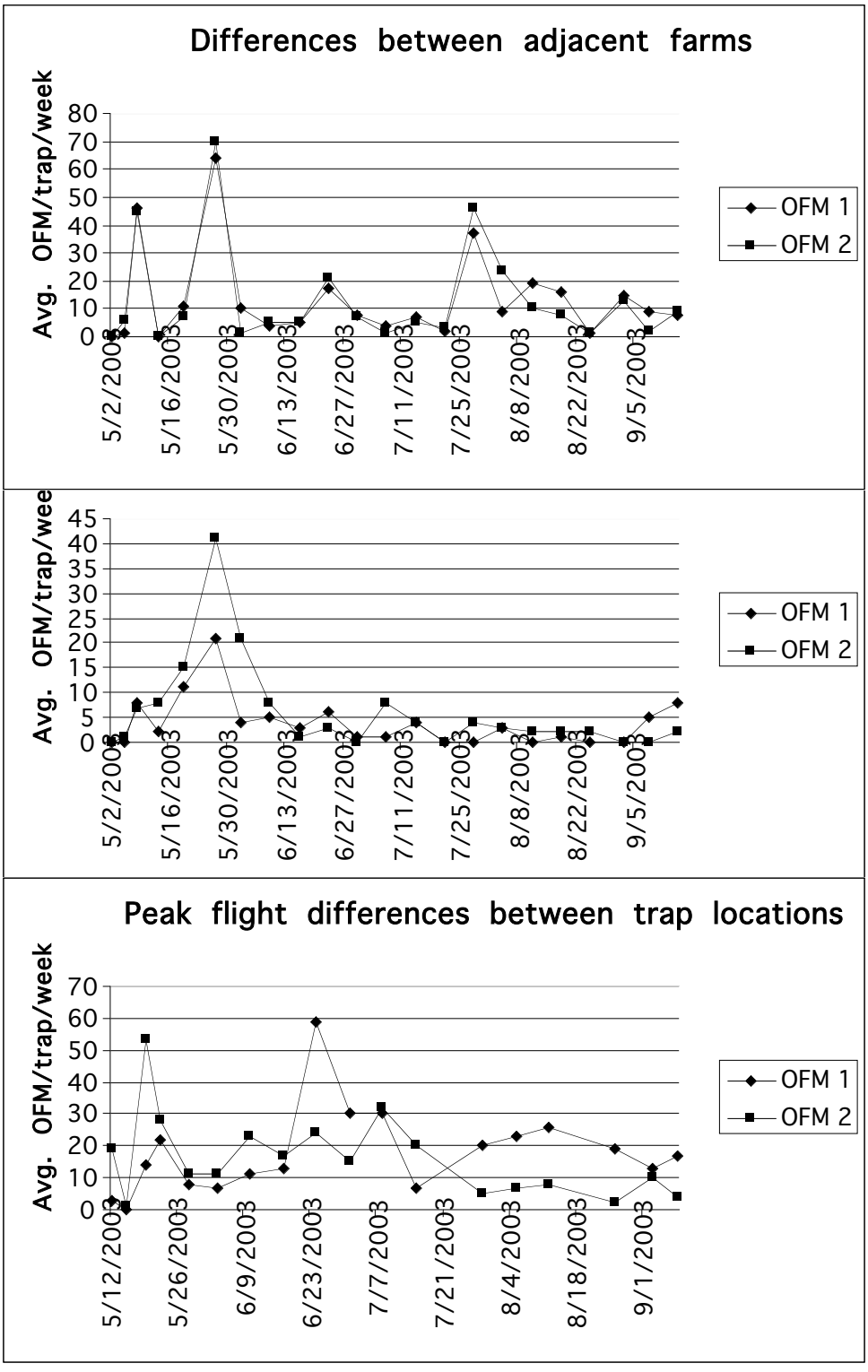


Figure 7 shows the differences in one farm between the OFM population in peaches (POFM1 and POFM2) and that in an apple block (OFM1 and OFM2) on the same farm. According to the Pennsylvania State University research, (unpublished data), OFM have a preference for peach shoots during the shoot growth phase and have a different rate of larval development when feeding on apples vs. peaches. Therefore you cannot rely on trap count data from peaches to plan for apple sprays or visa versa.

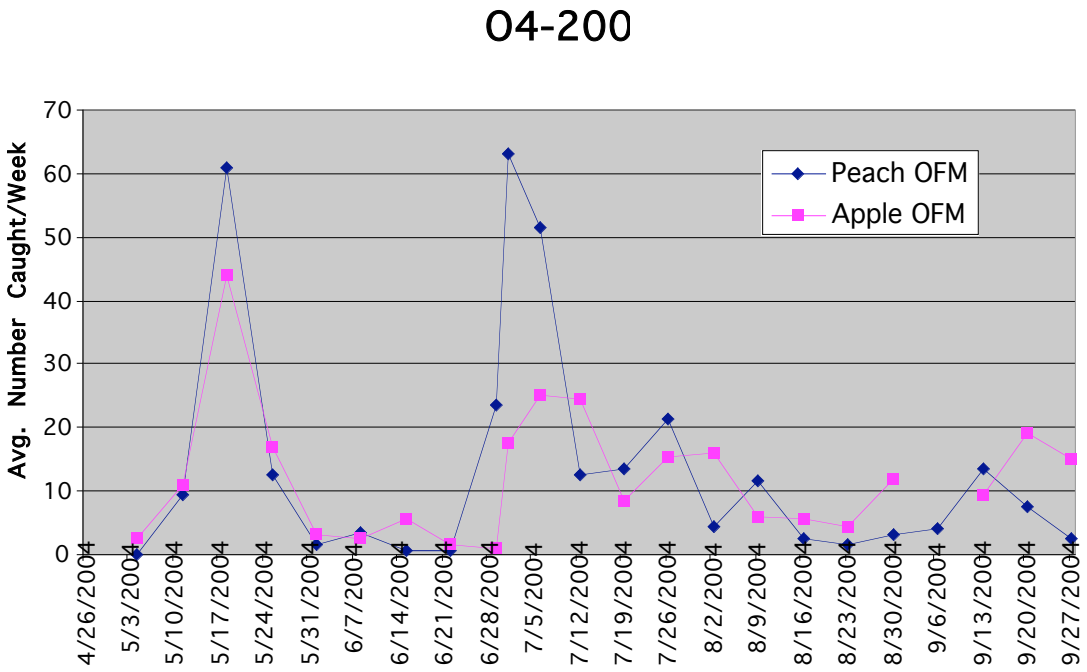


Figure 7. OFM flight in peaches often peaks about a week ahead of OFM trap catch data in apple.

Finally, it is important to know which pests are the primary target since the control timing for them differs. Although mating disruption for OFM will also disrupt LAW, the control timing for LAW using insecticides will be similar to codling moth timing, not OFM as shown in Figure 8. So if you have high populations of LAW in the area but not CM, there is in increased chance of fruit infestation with LAW. LAW can be easily misidentified as OFM since they both have an anal comb at the posterior end of the larva. This reinforces the need to identify the worms that are found in fruit to ensure the proper control strategy is taken.

Harvest evaluation:

Harvest evaluations in 2003 and 2004 (Table 1)resulted in good fruit quality with respect to pest defects. With the exception of one chemical control block in 2003, and the 3 mating disruption blocks, there was no internal lep infestation of fruit detected. In 2004, there was only 1% internal lep damage detected in adjacent presumably unsprayed orchards (check plots) compared to a much higher 22% in 2003. This indicates that there was significantly less success of penetration into the fruit by newly hatched larvae in 2004. This was likely due to the cool, wet, season.

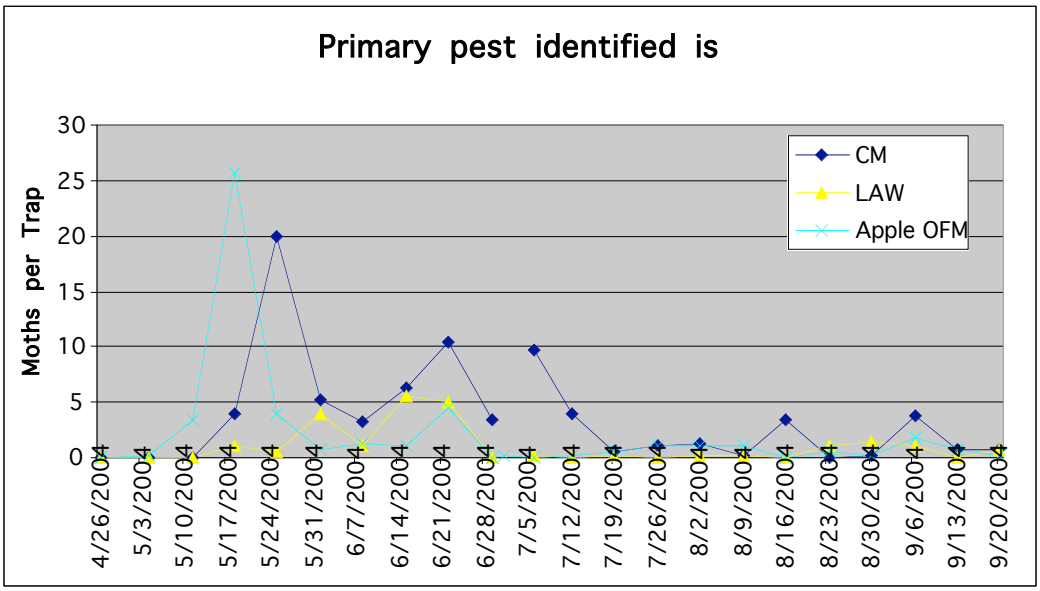


Figure 8. Trap catch data identify primary pest target in the internal lep complex. The recommended trap catch threshold for CM is 5 moths per trap per week, for OFM, 10 moths per trap per week. No threshold suggested for LAW.

Spray costs:

The cost of crop protectants continues to rise as new materials are registered. But at the same time, there have been more pyrethroids registered for use in NY for pome and stone fruit and generally at lower cost compared to other insecticide classes. The concern about the harmful effects on beneficials, such as predator mites is still an issue with pyrethroids. But there are many effective miticides available to fruit growers to combat this problem. Spray costs have increased overall since 2002 because of the internal lep issue with the risk of rejected apples at the processors or the risk of consumers or importers finding a worm in a fresh apple. Table 2 shows the number of applications of various insecticide/miticide classifications applied in 2003 and 2004.

The general trend noted in Western New York has been an increase in the number of cover applications using broad-spectrum insecticides, such as organophosphates (OPs) and pyrethroids (SP). The main reason for the increase has been the increased risk of internal lep pests infesting the fruit, and the cost of the new, more selective chemistry. Table 3 shows data from the National Agricultural Statistics Services for pesticide use in NY apples for 1999, 2001, and 2003 published on the web at http://www.nass.usda.gov/ny/statisticspub.htm. This data is for all of NY but correctly reflects the significant increase in the use of SP's in apple production and many cases replacing the use of an OP cover spray or 2.

Table 1. Harvest evaluations for 2003 and 2004.

	% Int Lep		% Sting		% OBLR		% OWOBLR		% AM		% SJS/OSS		% TPB	
Apple Blocks	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
M1	0.0	0.0	0.3	0.0	2.3	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
M2	0.0		1.0		3.0		2.0		0.0		0.0		0.0	
M3-Assail		0.0		0.9		0.8		0.3		0.0		0.0		0.1
M3-GS		0.0		1.0		2.3		0.2		0.0		0.0		0.6
N1b3	0.5		0.9		0.5		1.4		0.0		0.9		0.2	
N4a	0.0		0.0		0.0		0.3		0.0		0.0		0.3	
N4b	0.0		0.0		0.0		0.0		0.0		0.0		0.3	
O2-GS	6.5	0.0	0.8	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
O2-Im	1.7	0.0	0.1	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
O3	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
O4	0.0	0.0	0.0	0.8	13.0	1.2	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.3	0.0
W3a	0.0		1.0		2.3		0.3		0.0		0.0		0.0	
W3b	0.0	0.0	0.0	0.8	1.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4
W4a		0.0		1.6		1.2		0.0		0.0		0.0		0.0
W4 b	0.0		0.7		0.0		0.0		0.0		0.0		0.0	
W5a	0.0		1.0		4.7		1.0		0.0		0.0		0.0	
W5b	0.0		0.3		2.0		0.0		0.0		0.0		0.3	
W6a	0.0		0.0		16.7		0.3		0.0		0.0		0.0	
W6b	0.0	0.0	3.7	0.0	0.0	0.8	0.0	0.4	0.0	0.0	0.0	1.2	0.0	0.0
W7	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.0	1.7	0.0	0.0	0.0
Check Plot														
W3c		1		0		7		0		60		0		1
W6c	22.0	1.0	0.0	2.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mating Disruption Trials														
N8	1.3	0.0	0.3	0.5	2.0	0.0	1.7	0.1	0.3	0.0	0.0	0.0	0.3	0.9
W4 a	2.8		4.5		0.0		0.0		0.0		0		0	
N1b2	1.0		0.8		2.5		1.2		0.7		2.7		0	

Table 2. Number of applications 2003/2004

Apple Blocks	Pyrethroid	OP	Carbamate	Avaunt	B.t.	MD	IGR	Neo
M1	5/4	3/3	0/0	0/0	2/2	0	0/0	0/0
M3	2/2	6/6	0/0	0/0	0/0	0/0	0/0	0/0
N8 GS	0/1	6.5/6	0/0	0/0	0/0	1/1	0/2	0/0
N8 IM	0/1	6.5/7	0/0	0/0	0	0/0	0/0	0/0
O2 GS	4/2.5	5/4.5	0/0	0/0	0/0	0/0	0/1	0/2
O2 IM	3/1	8/8	0/0	0/0	0/0	0/0	0/0	0/0
O3	6/nd	5/nd	0/nd	0/nd	0/nd	0/nd	0/nd	0/nd
O4	nd/1	nd/7	nd/1	nd/0	nd/.5	0/0	0/0	nd/0
O5	6/2	1/4	0/0	0/0	0/0	0/0	0/1	0/0
W3	nd/0	nd/5	nd/0	nd/0	nd/2	nd/0	nd/1	nd/0
W4a	0/0	4/3	0/0	1/2	1/0	3/0	0/1	0/0
W5	4/3	1/4	0/1	o/0	2/1	0/0	0/0	0/0
W6	7/6	2/2	1/1	0/0	1/0	0/0	0/0	0/0
W7	nd/4	nd/3	nd0	nd/0	nd2	nd/0	nd/0	0/0
W11	nd/6	nd/3	nd/0	nd/1	nd/0	nd/0	nd/0	nd/0
Avg 2004	**2.4**	**4.7**	**0.2**	**0.2**	**0.5**	**0.1**	**0.4**	**0.8**

Avg cost per acre: $133.52
Avg cost in blocks that used new chemistry: $174.17

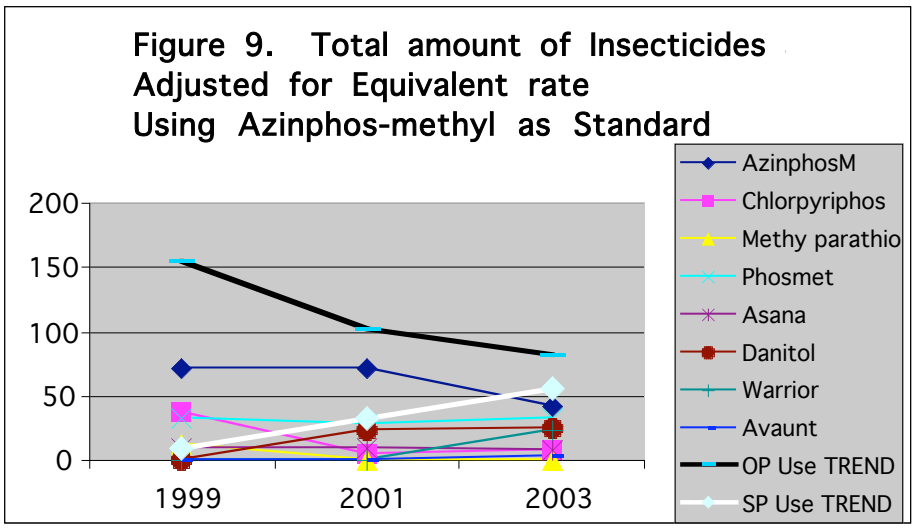
Table 3. Data reported by National Agricultural Statistics Service for insecticide use in NY apple production.

	1999			2001			2003		
	% acreage	# sprays	1,000 lb applied	% acreage	# sprays	1,000 lb applied	% acreage	# sprays	1,000 lb applied
AzinphosM (OP)	67	3.1	72	77	3.3	70.6	64	2.6	41.5
Chlorpyriphos (OP)	60	1.8	59.7	13	1.3	6.5	32	1	14.5
Methy parathion (OP)	25	1.4	17.3	0	0	0	0	0	0
Phosmet (OP)	43	2.2	59.7	50	1.9	64.5	42	3.2	68.8
Asana (SP)	26	1.2	0.6	12	1.3	0.4	18	1.4	0.5
Danitol (SP)	0	0	0	42	1.9	8.6	49	2.1	8
Warrior (SP)	0	0	0	0	0	0	41	2	1.2
Avaunt	0	0	0	0	0	0	7	1.3	0.4

Data from http://www.nass.usda.gov/ny/statisticspub.htm

Figure 9 shows the total amount used of each of the OPs, SPs and Avaunt, after adjusting the rates to the equivalent of azinphosmethyl. If the standard use rate of Azinphosmethyl is .5 lb., and the use rate of phosmet is 1.17, the adjusted rate based on the azinphos-methyl standard rate, is .5 divided by 1.17, or .43. If the total amount of phosmet applied is 64.5 lb., the adjusted rate is .43 times 64.5, or 27.74 (in 1000 lbs). It is even more critical to use this adjusted rate to better view what is happening to pyrethroids that are applied in ounces per acre, not lbs. per acre. If the amount of active ingredient of Warrior per acre applied is .03 lb./acre, compared to the use rate of azinphosmethyl at .59 lb./acre, you get a correction factor of 19.67 times the total amount of

Warrior used in 2003, resulting in 23.60 thousand lbs. If the OPs and SPs are grouped and sum using this adjusted total amount used, you can better see the change in the choice of chemistry in NY. As shown by the OP Use Trend, you can see the total amount of OPs is declining and being replaced by the increasing trend of SP use as more f them are made available on the market at a low cost.



Summary:

Using pheromone traps is essential in identification of OFM and CM first moth trap catch to set biofix to use in the degree-day models.

Using pheromone traps will also provide relative numbers of insect pressure and identify the predominant pest in the internal lep complex, as well as peak flight.

Using mating disruption will reduce trap counts in the orchard to essentially zero, but non-disrupted populations must be used to run the degree day timing model to know when to apply sprays for egg hatch.

Insecticide applications have increased in general in areas where infested fruit has been detected in previous seasons.

Pest damage, including OBLR, has declined. Cool, wet, weather has likely contributed to the lower pest pressure.

With internal lep pressure declining to more manageable levels, it should be possible to cut back on the number of brad spectrum cover insecticides.

Rotation between chemistry classes for each generation of egg hatch will be important since there are plenty of regions where resistant has developed to pyrethroids and OP leaving few alternatives for control.